SD11
U57
#15

REFERENCE HANDBOOK FOR FORESTERS

U. S. Department of Agriculture Forest Service
State & Private Forestry Northeastern Area

LIBRARY
NAEFC 15
JAN 1980
AUG 13 1984
ROCKY MOUNTAIN STATION

Prepared by

Burl S. Ashley

Field Representative, Resource Management

Northeastern Area, State & Private Forestry

Morgantown, West Virginia

January, 1980

This handbook revises and supersedes NA-FR-2
"Field Reference Handbook for Service Foresters."

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

CONTENTS

	Page
International Tree Scale	1
Scribner Tree Scale	2
Doyle Tree Scale	3
International Log Scale	4
Scribner Log Scale	5
Doyle Log Scale	6
Pulpwood Measurement	7
Lumber Scale	8
Stave Bolt and Heading Bolt Volumes in Standing Trees	9
Shortcut Formulas: Pulpwood	10
Shortcut Formulas: Sawtimber	11
Ratios for Cruising by Basal Area	12
Quick Cruise Computer - Cords	13
Quick Cruise Computer - Board Feet	14
Weight Table for Various Woods	15
Sugar Maple Tap Hole Computation Sheet	16
Rate of Growth - Growth Factor Table	17
Shortcut Calculations for Growth	18
Central Hardwood Spacing Table	19
Estimated Cost per Tree for Pruning Pine	20
Compound Interest Table	21
Number of Trees per Acre by Various Methods of Spacing	22
Basal Area Table	23
Number of Stems per Acre by Diameter and Basal Area	24
Firewood	25
Metric Conversion Factors	26
Elementary Statistical Considerations for Cruising	27&28
Ratio of Standard Deviation to Range for Simple Random Samples	29
Accuracy Level Table	30
Upland Central Hardwood Stocking Guide	31&32
Northern Hardwood Stocking Guide	33
Red Pine Stocking Guide	34
White Pine Stocking Guide	35

LIBRARY COPY

ROCKY MT. FOREST & RANGE

EXPERIMENT STATION

TREE SCALE
(International 1/4 Inch)

DBH (in.)	Number of 16-Foot Logs							
	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4
	Contents in Board Feet							
12	30	60	80	100	120			
14	40	80	110	140	160	180		
16	60	100	150	180	210	250	280	310
18	70	140	190	240	280	320	360	400
20	90	170	240	300	350	400	450	500
22	110	210	290	360	430	490	560	610
24	130	250	350	430	510	590	660	740
26	160	300	410	510	600	700	790	880
28	190	350	480	600	700	810	920	1020
30	220	410	550	690	810	930	1060	1180
32	260	470	640	790	940	1080	1220	1360
34	290	530	730	900	1060	1220	1380	1540
36	330	600	820	1010	1200	1380	1560	1740
38	370	670	910	1130	1340	1540	1740	1940
40	420	740	1010	1250	1480	1700	1920	2160
42	460	820	1100	1360	1610	1870	2120	2360

TREE SCALE
(Scribner)

DBH (in.)	Number of 16-Foot Logs						
	1	1 1/2	2	2 1/2	3	3 1/2	4
	Contents in Board Feet						
12	47	61	75	85	95	100	106
14	69	92	114	130	146	156	166
16	95	127	159	185	211	229	247
18	123	166	209	244	280	306	331
20	157	214	270	317	364	398	432
22	194	266	338	398	458	504	549
24	234	322	409	484	558	611	665
26	281	388	494	585	676	745	814
28	327	452	578	686	795	877	959
30	382	530	678	806	933	1028	1124
32	440	612	784	936	1089	1206	1322
34	498	695	892	1066	1239	1373	1507
36	563	789	1015	1216	1416	1572	1728
38	629	882	1135	1366	1596	1769	1942
40	703	988	1274	1532	1791	1993	2195

TREE SCALE
(Doyle)

DBH (in.)	Number of 16-Foot Logs							
	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4
	Contents in Board Feet							
12	20	30	40	50	60			
14	30	50	70	80	90	100		
16	40	70	100	120	140	160	180	190
18	60	100	130	160	200	220	240	260
20	80	130	180	220	260	300	320	360
22	100	170	230	280	340	380	420	460
24	130	220	290	360	430	490	540	600
26	160	260	360	440	520	590	660	740
28	190	320	430	520	620	710	800	880
30	230	380	510	630	740	840	940	1040
32	270	440	590	730	860	990	1120	1220
34	300	510	680	850	1000	1140	1300	1440
36	350	580	780	970	1140	1310	1480	1640
38	390	660	880	1100	1290	1480	1680	1860
40	430	740	990	1230	1450	1660	1880	2080
42	470	830	1100	1370	1620	1860	2100	2320

LOG SCALE
(International 1/4 Inch)

Diameter (Inches)	Length of Log (feet)					
	6	8	10	12	14	16
	Contents in Board Feet					
6	5	10	10	15	15	20
7	10	10	15	20	25	30
8	10	15	20	25	35	40
9	15	20	30	35	45	50
10	20	30	35	45	55	65
11	25	35	45	55	70	80
12	30	45	55	70	85	95
13	40	55	70	85	100	115
14	45	65	80	100	115	135
15	55	75	95	115	135	160
16	60	85	110	130	155	180
17	70	95	125	150	180	205
18	80	110	140	170	200	230
19	90	125	155	190	225	260
20	100	135	175	210	250	290
21	115	155	195	235	280	320
22	125	170	215	260	305	355
23	140	185	235	285	335	390
24	150	205	255	310	370	425
25	165	220	280	340	400	460
26	180	240	305	370	435	500
27	195	260	330	400	470	540
28	210	280	355	430	510	585
29	225	305	385	465	545	630
30	245	325	410	495	585	675

LOG SCALE
(Scribner)

Diameter (Inches)	Length of Log (feet)					
	6	8	10	12	14	16
	Contents in Board Feet (tens)					
8	1	1	2	2	2	3
9	1	2	3	3	3	4
10	2	3	3	3	4	6
11	2	3	4	4	5	7
12	3	4	5	6	7	8
13	4	5	6	7	8	10
14	4	6	7	9	10	11
15	5	7	9	11	12	14
16	6	8	10	12	14	16
17	7	9	12	14	16	18
18	8	11	13	16	19	21
19	9	12	15	18	21	24
20	11	14	17	21	24	28
21	12	15	19	23	27	30
22	13	17	21	25	29	33
23	14	19	23	28	33	38
24	15	21	25	30	35	40
25	17	23	29	34	40	46
26	19	26	31	37	44	50
27	21	27	34	41	48	55
28	22	29	36	44	51	58
29	23	31	38	46	53	61
30	26	33	41	49	57	66

LOG SCALE
(Doyle)

Diameter (Inches)	Length of Log (feet)					
	6	8	10	12	14	16
	Contents in Board Feet					
8	6	8	10	12	14	16
9	9	13	16	19	22	25
10	14	18	23	27	32	36
11	18	25	31	37	43	49
12	24	32	40	48	56	64
13	30	41	51	61	71	81
14	38	50	63	75	88	100
15	45	61	76	91	106	121
16	54	72	90	108	126	144
17	63	85	106	127	148	169
18	74	98	123	147	172	196
19	84	113	141	169	197	225
20	96	128	160	192	224	256
21	108	145	181	217	253	289
22	122	162	203	243	284	324
23	135	181	226	271	316	361
24	150	200	250	300	350	400
25	165	221	276	331	386	441
26	182	242	303	363	424	484
27	198	265	331	397	463	529
28	216	288	360	432	504	576
29	234	313	391	469	547	625
30	254	338	423	507	592	676

PULPWOOD MEASUREMENT
(Standing Trees)

CORDS

DBH (Inches)	8-Foot Sticks						
	1	2	3	4	5	6	7
5	.010	.018					
6	.018	.030	.043				
7	.025	.039	.056	.074			
8	.032	.050	.070	.092	.116		
9	.040	.061	.085	.112	.140	.168	
10	.049	.074	.101	.132	.167	.200	.239
11	.059	.087	.119	.155	.195	.233	.280
12	.070	.100	.138	.180	.225	.271	.324
14	.095	.134	.179	.233	.291	.351	.419
16	.120	.168	.222	.290	.361	.437	.521
18	.146	.208	.270	.350	.439	.531	.634
20	.186	.246	.320	.416	.522	.632	.755
22	.220	.294	.374	.494	.612	.739	.883

Source: S. R. Gevorkiantz, Lake States Forest Experiment Station Technical Note No. 241, 1945.

LUMBER SCALE

Thickness and Width (Inches)	Length (Feet)					
	6	8	10	12	14	16
	Contents in Board Feet					
1x3	1.5	2	2.5	3	3.5	4
1x4	2	2.6	3.3	4	4.6	5.3
1x5	2.5	3.3	4	5	6	6.6
1x6	3	4	5	6	7	8
1x7	3.5	4.6	6	7	8	9.3
1x8	4	5.3	6.6	8	9.3	10.6
1x10	5	6.6	8.3	10	11.6	13.3
1x12	6	8	10	12	14	16
2x4	4	5.3	6.6	8	9.3	10.6
2x6	6	8	10	12	14	16
2x8	8	10.6	13.3	16	18.6	21.3
2x10	10	13.3	16.6	20	23.3	26.6
2x12	12	16	20	24	28	32
2x14	14	18.6	23.3	28	32.6	37.3
3x6	9	12	15	18	21	24
3x8	12	16	20	24	28	32
3x10	15	20	25	30	35	40
3x12	18	24	30	36	42	48
4x4	8	10.6	13.3	16	18.6	21.3
6x6	18	24	30	36	42	48

HEADING BOLTS

DBH (In.)	Number of 24-inch Cuts									
	1	2	3	4	5	6	7	8	9	10
	Volume in Chord Feet									
18	4.6	9.2	13.7	18.1	22.3					
20	5.1	10.2	15.2	20.1	24.9	29.5	34.0	38.4	42.7	
22	5.6	11.2	16.7	22.1	27.3	32.4	37.3	42.0	46.5	50.7
24	6.1	12.0	17.6	22.9	27.9	32.6	37.0	41.0	44.9	48.5
26	6.7	13.1	19.2	25.0	30.5	35.7	40.6	45.2	49.5	53.0
28	7.2	14.1	20.7	27.0	33.0	38.7	44.1	49.2	54.0	58.5
30	7.7	15.1	22.2	29.0	35.5	41.7	47.6	53.2	58.5	63.5
32	8.2	16.1	23.7	31.0	38.0	44.7	51.1	57.2	63.0	68.5

*From: University of Missouri AGR. EXT. SVC. CIR 671 and EXT. SVC. Kansas State University, 3A-574-4-500.

SHORTCUT FORMULAS
for
Determining Volumes with a 10-factor Prism or Gauge

PULPWOOD
(Cords)

1. $\frac{\text{Average number of countable trees per sample (av. no. of 8-ft. sticks per tree + 1)}}{2}$ = cords per acre

   Example: The countable trees averaged 2.5 8-foot sticks.
   The average number of countable trees per sample was 6.

   $\frac{6\ (2.5 + 1)}{2} = 10.5$ cords per acre

2. $\frac{\text{Number of 8-foot sticks in countable trees + number of countable trees}}{2 \times \text{number of point samples}}$ = cords per acre

   Example: 48 trees were tallied.
   120 8-foot sticks were tallied in countable trees.
   8 samples were taken.

   $\frac{120 + 48}{2 \times 8} = 10.5$ cords per acre

3. $\frac{\text{Number of 8-foot sticks in countable trees x *}}{\text{number of point samples}}$ = cords per acre

   * Use .9 if trees av. 1 stick
   .7 if trees av. 2 sticks
   .65 if trees av. 3 sticks
   .6 if trees av. 4 or more sticks

   Example: 10 samples were taken.
   132 8-foot sticks were counted.
   Average number of sticks per tree - 2.

   $\frac{132 \times .7}{10} = 9.24$ cords per acre

4. Cords can be converted to tons by using the appropriate TONS PER STANDARD CORD RATIO on page 15.

SHORTCUT FORMULAS
for
Determining Volumes with a 10-factor Prism or Gauge

SAWTIMBER
(Board Feet - International Rule)

1. $\frac{\text{Number of 16-foot logs in countable trees} \times *}{\text{number of point samples}}$ = board feet per acre

* Use 750 if trees av. 1 log
660 if trees av. 1.5 logs
625 if trees av. 2.0 logs
600 if trees av. 2.5 logs
580 if trees av. 3.0 logs

Example: 8 point samples were taken.
22.5 16-foot logs were tallied in countable trees.
Average number of logs per tree - 2.5.

$$\frac{22.5 \times 600}{8} = 1{,}688 \text{ board feet per acre}$$

2. To determine approximate Doyle Rule volume, apply factor from following table to the calculated International Rule volume:

Average DBH	Factor
12"	.50
16"	.65
20"	.75
24"	.85
28"	.90
32"	.95

RATIOS FOR CRUISING BY BASAL AREA

I. SAWTIMBER -- Basal area / board foot ratios by various merchantable lengths:

1.0	16-foot log	--	75	BF	to 1	sq.	ft.
1.5	" "	--	100	"	" "	"	"
2.0	" "	--	125	"	" "	"	"
2.5	" "	--	150	"	" "	"	"
3.0	" "	--	175	"	" "	"	"
3.5	" "	--	200	"	" "	"	"

Ratios for other numbers of 16-foot logs can be computed by using the following formula:

25 + (av. no. of logs per tree x 50) =

BF / sq. ft. ratio

Example: Average number of 16-foot logs per tree is 2.72.

25 + (2.72 x 50) = 161 BF to 1 sq. ft.

To obtain board foot volume, multiply ratio by number of square feet of basal area involved.

II. PULPWOOD or FIREWOOD -- Basal area / cord ratios by various merchantable lengths:

1 -	8' stick	--	.089	cords	to 1	sq.	ft.
2 -	" "	--	.143	"	" "	"	"
3 -	" "	--	.195	"	" "	"	"
4 -	" "	--	.249	"	" "	"	"
5 -	" "	--	.302	"	" "	"	"

Ratios for other numbers of 8-foot sticks can be computed by using the following formula:

$$\left[.037 + \text{av. no. of sticks per tree} \times .053\right] =$$

cords / sq. ft. ratio

Example: Average number of 8-foot sticks per tree is 3.3.

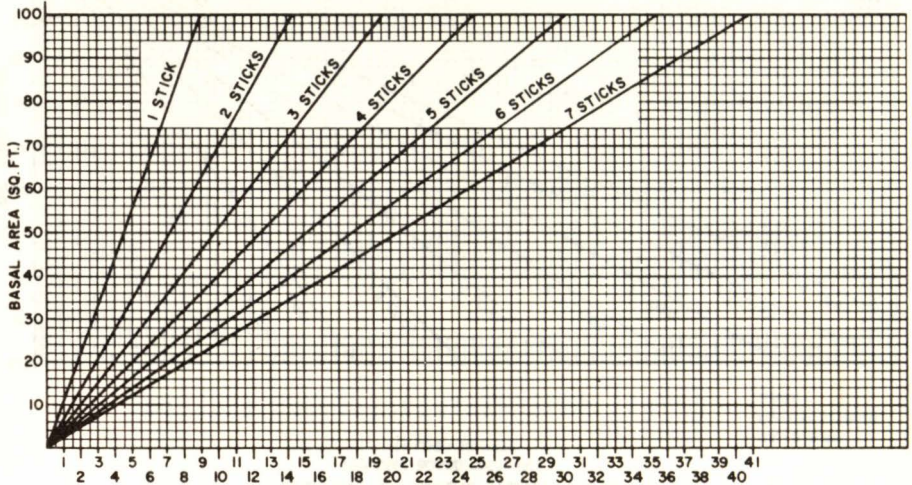
.037+(3.3 x .053) = .2119 cords to 1 sq. ft.

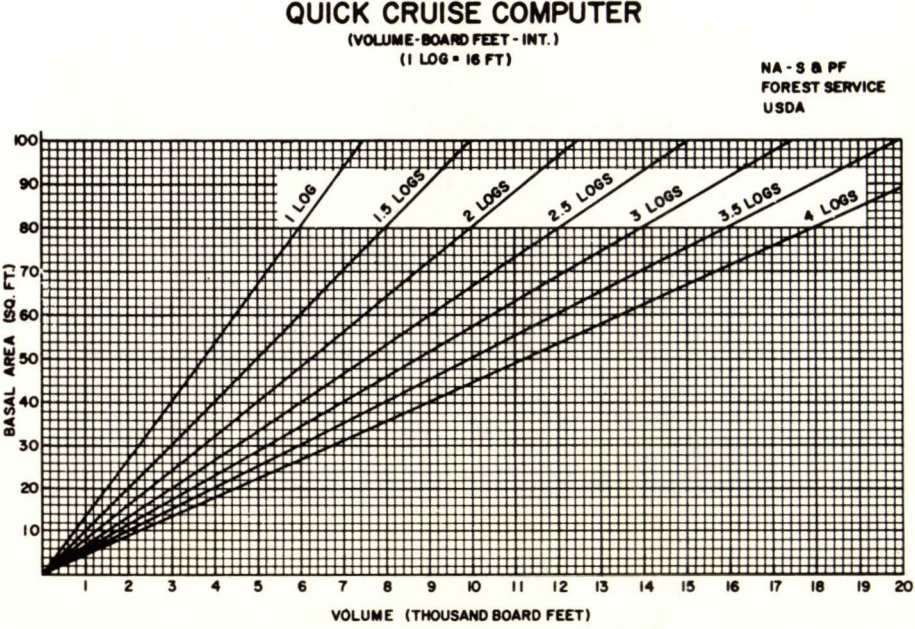
To obtain cord volume, multiply ratio by number of square feet of basal area involved.

QUICK CRUISE COMPUTER

VOLUME - CORDS
(1 STICK = 8 FT.)

NA - S & PF
FOREST SERVICE
USDA




QUICK CRUISE COMPUTER
(VOLUME - BOARD FEET - INT.)
(1 LOG = 16 FT)
NA - S & PF
FOREST SERVICE
USDA
1 LOG
1.5 LOGS
2 LOGS
2.5 LOGS
3 LOGS
3.5 LOGS
4 LOGS
BASAL AREA (SQ. FT.)
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
VOLUME (THOUSAND BOARD FEET)

WEIGHT TABLE FOR VARIOUS WOODS

	Weight Per Standard Cord (Pounds)	Tons Per Standard Cord Ratio	Weight Per 1000 B.F. of Green Lumber (Pounds)
Ash, white	4300	2.2	4000
Aspen	3900	2.0	3600
Basswood	3800	1.9	3500
Beech	4900	2.5	4500
Birch, yellow	5100	2.6	4800
Birch, white	4500	2.3	4200
Cedar, red	3300	1.7	3100
Cedar, n. white	2500	1.3	2300
Cherry, black	4000	2.0	3800
Cottonwood	4400	2.2	4100
Elm	5000	2.5	4600
Gum, red & black	4500	2.3	4200
Hackberry	4500	2.3	4200
Hemlock	4500	2.3	4200
Hickory	5700	2.9	5300
Locust, black	5200	2.6	4800
Maple, hard	5300	2.7	4600
Maple, soft	4300	2.2	3900
Oak, red	5700	2.9	5200
Oak, white	5600	2.8	5200
Pine, red	3800	1.9	3500
Pine, shortleaf	4700	2.4	4300
Pine, white	3200	1.6	3000
Poplar, yellow	3400	1.7	3200
Spruce	3000	1.5	2800
Sycamore	4700	2.4	4300
Tamarack	4200	2.1	3900
Walnut, black	5200	2.6	4800

SUGAR MAPLE TAP HOLE COMPUTATION SHEET
POINT SAMPLE METHOD
(10-factor)

DBH																TOTAL
10"	18	37	55	73	92	110	128	146	165	183	201	220	238	256	275	
12"	13	25	38	51	64	76	89	102	114	127	140	152	165	178	191	
14"	9	19	28	38	47	56	66	75	85	94	103	113	122	132	141	
16"	14	29	43	58	72	86	101	115	130	144	158	173	187	202	216	
18"	11	23	34	46	57	68	80	91	103	114	125	137	148	160	171	
20"	14	28	41	55	69	83	97	110	124	138	152	166	179	193	207	
22"	11	23	34	46	57	68	80	91	103	114	125	137	148	160	171	
24"	10	19	29	38	48	58	67	77	86	96	106	115	125	134	144	
26"	11	22	32	43	54	65	76	86	97	108	119	130	140	151	162	
TOTAL																

For number of tap holes per acre -- total last numbers in each diameter class -- then divide this total by number of point samples taken.

(Total) _____

_____ = _____ tap holes per acre

_____
(point samples)

(Tap holes per acre) _____ x (acres) _____ = _____ total for woodland

RATE OF GROWTH
(GROWTH FACTOR TABLE)

DBH	Rings Per Inch											
	4	5	6	7	8	9	10	11	12	13	14	15
4"	.282	.225	.188	.161	.141	.125	.113	.102	.094	.087	.080	.075
5"	.220	.177	.147	.126	.110	.098	.088	.080	.073	.068	.063	.059
6"	.181	.145	.121	.103	.091	.080	.072	.065	.060	.056	.052	.048
7"	.153	.123	.103	.088	.077	.068	.061	.056	.051	.047	.044	.041
8"	.133	.106	.089	.076	.067	.059	.053	.048	.044	.041	.038	.035
9"	.116	.093	.078	.067	.058	.052	.047	.042	.039	.036	.033	.031
10"	.105	.084	.070	.060	.053	.047	.042	.038	.035	.032	.030	.028
11"	.095	.076	.063	.054	.047	.042	.038	.034	.032	.029	.027	.025
12"	.087	.070	.058	.050	.044	.039	.035	.032	.029	.027	.025	.023
13"	.080	.064	.053	.046	.040	.035	.032	.029	.027	.025	.023	.021
14"	.074	.059	.049	.042	.037	.033	.030	.027	.025	.024	.021	.020
15"	.069	.055	.046	.039	.034	.031	.028	.025	.023	.021	.020	.018
16"	.064	.052	.043	.037	.032	.029	.026	.023	.021	.020	.018	.017
17"	.061	.048	.040	.035	.030	.027	.024	.022	.020	.019	.017	.016
18"	.057	.046	.038	.033	.029	.025	.023	.021	.019	.018	.016	.015
19"	.054	.043	.036	.031	.027	.024	.022	.020	.018	.017	.015	.014
20"	.051	.041	.034	.029	.025	.023	.020	.019	.017	.016	.015	.014
21"	.049	.039	.033	.028	.024	.022	.020	.018	.016	.015	.014	.013
22"	.046	.037	.031	.027	.023	.021	.019	.017	.015	.014	.013	.012

Procedure

1. Determine GROWTH FACTOR by applying average DBH and average rings per inch to above table.
2. Compute annual rate of growth of BASAL AREA, CORDS, TONS, BOARD FEET (International), or CUBIC FEET by multiplying amount of good growing stock in each category by the GROWTH FACTOR.
3. Multiply GROWTH FACTOR by 100 for growth percent.

SHORTCUT CALCULATIONS FOR GROWTH

1. Rule-of-thumb for Central Hardwoods:

   Estimated No. of trees per acre above 9" DBH x __*__ = Annual growth rate (board feet)

   * Insert 5 for good site
   4 for average site
   3 for poor site

2. Quick growth computation for an individual tree:

$$\frac{\text{Future volume after increment of 2" DBH - present volume}}{\text{RPI}} = \text{Annual growth}$$

3. Shortcut growth formulas:

   a. $\frac{4 \times \text{volume per acre}}{\text{DBH} \times \text{RPI}}$ = Growth/acre/year (volume)

   b. $\frac{4 \times \text{basal area per acre}}{\text{DBH} \times \text{RPI}}$ = Growth/acre/year (basal area)

   c. Ingrowth:

      (1) No. of 10" DBH trees/acre x 5 = BF ingrowth/acre/year

      (2) $\frac{\text{Basal area in 10" DBH trees} \times 91.5}{\text{RPI}}$ = Board feet/acre/year

CENTRAL HARDWOOD SPACING TABLE

Diameter (Inches)	Maximum Stocking "A"-Level Spacing (feet)	Minimum Stocking "B"-Level Spacing (feet)
2	4.6	6.5
3	6.1	8.2
4	7.6	9.9
5	9.0	11.6
6	10.3	13.4
7	11.6	15.0
8	13.0	17.0
9	14.3	18.7
10	15.6	20.4
11	17.0	22.1
12	18.1	23.8
13	19.4	25.6
14	20.8	27.2
15	21.9	29.0

RULE-OF-THUMB:

For "A"-level stocking spacing, multiply diameter by 1.5

For "B"-level stocking spacing, multiply diameter by 2.0

ESTIMATED COST PER TREE FOR PRUNING PINE

Height (Feet)	Average Number of Minutes Per Tree	Hourly Labor Rate						
		$2.00	$3.00	$4.00	$5.00	$6.00	$7.00	$8.00
6	3.2	.11	.16	.21	.27	.32	.38	.43
7	3.6	.12	.18	.24	.30	.36	.42	.48
8	4.0	.13	.20	.27	.33	.40	.47	.53
9	4.4	.15	.22	.29	.37	.44	.51	.58
10	4.8	.16	.24	.32	.40	.48	.56	.64
11	5.6	.19	.28	.37	.47	.56	.65	.74
12	6.4	.21	.32	.43	.53	.64	.75	.85
13	7.2	.24	.36	.48	.60	.72	.84	.96
14	8.1	.27	.41	.54	.68	.81	.95	1.08
15	9.6	.32	.48	.64	.80	.96	1.12	1.28
16	10.8	.36	.54	.72	.90	1.08	1.26	1.44
17	12.0	.40	.60	.80	1.00	1.20	1.40	1.60

COMPOUND INTEREST TABLE

Years	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1	1.040	1.050	1.060	1.070	1.080	1.090	1.100	1.110	1.120	1.130	1.140	1.150
2	1.082	1.103	1.124	1.145	1.166	1.188	1.210	1.232	1.254	1.277	1.300	1.323
3	1.125	1.158	1.191	1.225	1.260	1.295	1.331	1.368	1.405	1.443	1.482	1.521
4	1.170	1.216	1.262	1.311	1.360	1.412	1.464	1.518	1.574	1.630	1.689	1.749
5	1.217	1.276	1.338	1.403	1.469	1.539	1.611	1.685	1.762	1.842	1.925	2.011
6	1.265	1.340	1.419	1.501	1.587	1.677	1.772	1.870	1.974	2.082	2.195	2.313
7	1.316	1.407	1.504	1.606	1.714	1.828	1.949	2.076	2.211	2.353	2.502	2.660
8	1.369	1.477	1.594	1.718	1.851	1.993	2.144	2.305	2.476	2.658	2.853	3.059
9	1.423	1.551	1.689	1.838	1.999	2.172	2.358	2.558	2.773	3.004	3.252	3.518
10	1.480	1.629	1.791	1.967	2.159	2.367	2.594	2.839	3.106	3.395	3.707	4.046
15	1.801	2.079	2.397	2.759	3.172	3.642	4.177	4.785	5.474	6.254	7.138	8.137
20	2.191	2.653	3.207	3.870	4.661	5.604	6.728	8.062	9.646	11.523	13.743	16.367
25	2.666	3.386	4.292	5.427	6.848	8.623	10.835	13.585	17.000	21.231	26.462	32.919
30	3.243	4.322	5.743	7.612	10.063	13.268	17.449	22.892	29.960	39.116	50.950	66.212
35	3.946	5.516	7.686	10.677	14.785	20.414	28.102	38.575	52.800	72.069	98.100	133.176
40	4.801	7.040	10.286	14.974	21.725	31.409	45.259	65.001	93.051	132.782	188.884	267.864

NUMBER OF TREES PER ACRE BY VARIOUS METHODS OF SPACING

Spacing (Feet)	Trees (Number)	Spacing (Feet)	Trees (Number)	Spacing (Feet)	Trees (Number)
2x2	10,890	7x9	691	12x15	242
3x3	4,840	7x10	622	12x18	202
4x4	2,722	7x12	519	12x20	182
4x5	2,178	7x15	415	12x25	145
4x6	1,815	8x8	681	13x13	258
4x7	1,556	8x9	605	13x15	223
4x8	1,361	8x10	544	13x20	168
4x9	1,210	8x12	454	13x25	134
4x10	1,089	8x15	363	14x14	222
5x5	1,742	8x25	218	14x15	207
5x6	1,452	9x9	538	14x20	156
5x7	1,245	9x10	484	14x25	124
5x8	1,089	9x12	403	15x15	194
5x9	968	9x15	323	15x20	145
5x10	871	10x10	436	15x25	116
6x6	1,210	10x12	363	16x16	170
6x7	1,037	10x15	290	16x20	136
6x8	908	10x18	242	16x25	109
6x9	807	11x11	360	18x18	134
6x10	726	11x12	330	18x20	121
6x12	605	11x15	264	18x25	97
6x15	484	11x20	198	20x20	109
7x7	889	11x25	158	20x25	87
7x8	778	12x12	302	25x25	70

BASAL AREA TABLE

Diameter (Inches)	Area (Sq. Ft.)	Diameter (Inches)	Area (Sq. Ft.)
1	.006	21	2.405
2	.022	22	2.640
3	.049	23	2.885
4	.087	24	3.142
5	.136	25	3.41
6	.196	26	3.69
7	.267	27	3.98
8	.349	28	4.28
9	.442	29	4.59
10	.545	30	4.91
11	.660	31	5.24
12	.785	32	5.59
13	.922	33	5.94
14	1.069	34	6.30
15	1.227	35	6.68
16	1.396	36	7.07
17	1.576	37	7.47
18	1.767	38	7.88
19	1.969	39	8.30
20	2.181	40	8.73

NUMBER OF STEMS PER ACRE
by
Diameter and Basal Area

B.A.	Average Diameter															
Sq. Ft.	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"	14"	16"	18"	20"	22"	24"
10	204	115	74	51	38	29	23	18	15	12.7	9.4	7.2	5.7	4.6	3.8	3.2
20	408	230	147	102	75	58	45	37	30	25.5	18.7	14.3	11.3	9.2	7.6	6.4
30	612	345	221	153	112	86	68	55	45	38.2	28.1	21.5	17.0	13.7	11.4	9.5
40	816	460	294	204	150	115	90	73	61	50.9	37.4	28.6	22.6	18.3	15.2	12.7
50	1020	575	368	255	187	143	113	92	76	63.7	46.8	35.8	28.3	22.9	19.0	15.9
60	1225	690	441	306	225	172	136	110	91	76.4	56.1	43.0	34.0	27.5	22.7	19.1
70	1429	805	515	357	262	201	158	128	106	89.1	65.5	50.1	39.6	32.1	26.5	22.3
80	1633	920	588	408	300	229	181	147	121	101.8	74.8	57.3	45.3	36.6	30.3	25.4
90	1835	1034	662	459	337	258	204	165	135	114.6	84.2	64.4	50.9	41.2	34.1	28.6
100	2041	1149	735	510	375	287	226	183	152	127.3	93.5	71.6	56.6	45.8	37.9	31.8

Examples: 1.) 30 square feet - 9 inch trees = 68 trees.

2.) 75 square feet - 10 inch trees = (70 sq. ft. = 128 trees + 5 sq. ft. = 9 trees) = total of 137 trees.

FIREWOOD

I. Approximate BTU content:

1 pound of wood = 6,000 - 7,200 BTU
1 pound of coal = 12,000 BTU
1 pound of fuel oil = 18,000 BTU

1 cord of dry wood = 1 ton of coal = 200 gallons of fuel oil.

II. Measurement:

A. 1 standard cord (4'x4'x8') = 128 cubic feet.
The solid content depends on size and straightness -
large straight sticks -- 1 cord = 90 cubic feet
small crooked sticks -- 1 cord = 70 cubic feet
average -- 1 cord = 80 cubic feet

B. For weight by species, see the table on page 15.

C. For Cord Table, see page 7.

D. Formula for cubic feet per tree (works best for pine):

Divide DBH by 2, subtract 1, square remainder --

$$\left(\frac{D}{2} - 1\right)^2$$

Example: DBH = 10

$$\left(\frac{10}{2} - 1\right)^2 = 16 \text{ cubic feet}$$

E. Computing cubic feet per tree, number of trees, or acres of trees (works best on small hardwoods) --

Basal area (DBH + *) = cubic feet *Use 12 - site index 50
15 - site index 60
18 - site index 70
20 - site index 80
22 - site index 90

Example: Average DBH - 8"
Basal area - 25 sq. ft.
Site index - 60
25 (8 + 15) = 575 cubic feet
575 ÷ 80 = 7.19 cords

METRIC CONVERSION FACTORS

MULTIPLY	BY	OR	DIVIDE	BY	TO OBTAIN
Acres	0.405		Acres	2.471	Hectares
Centimeters	0.394		Centimeters	2.540	Inches
Chains	20.12		Chains	.050	Meters
Feet	0.305		Feet	3.281	Meters
$Feet^2/acre$	0.230		$Feet^2/acre$	4.356	$Meters^2/hectare$
$Feet^3$	.0283		$Feet^3$	35.311	$Meters^3$
Gallons	3.785		Gallons	.264	Liters
Hectares	2.471		Hectares	0.405	Acres
Inches	2.540		Inches	0.394	Centimeters
$Inches^3$	.0164		$Inches^3$	61.013	Liters
Kilometers	.621		Kilometers	1.609	Miles
Liters	61.013		Liters	.0164	$Inches^3$
Liters	.264		Liters	3.785	Gallons
Meters	.199		Meters	5.03	Rods
Meters	.050		Meters	20.12	Chains
Meters	3.281		Meters	0.305	Feet
$Meters^2/hectare$	4.356		$Meters^2/hectare$	0.230	$Feet^2/acre$
$Meters^3$	35.311		$Meters^3$	.0283	$Feet^3$
Miles	1.609		Miles	.621	Kilometers
Number/acre	2.471		Number/acre	0.405	Number/hectare
Number/hectare	0.405		Number/hectare	2.471	Number/acre
Rods	5.03		Rods	.199	Meters

ELEMENTARY STATISTICAL CONSIDERATIONS FOR CRUISING

A. FORMULAS

1. Mean (M) -- $\frac{\text{Total for samples}}{\text{Number of samples}}$

2. Standard Deviation (SD) -- $\sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N-1}}$

3. Coefficient of Variation (C) -- $100\sqrt{\left(\frac{N}{N-1}\right)\left(\frac{N\Sigma X^2}{(\Sigma X)^2} - 1\right)}$ or $\frac{SD}{M}$

4. Limit of Error (E) -- $\frac{C}{\sqrt{N}}$ (number of samples)

5. Number of Samples (N) -- $\frac{C^2}{E^2}$ for 68% accuracy level; or

$\frac{4C^2}{E^2}$ for 95% accuracy level.

B. SHORTCUT PROCEDURE FOR COMPUTING ERROR (E):

1. Determine range of samples by subtracting low sample from high sample. This is (R).

2. Refer to Table I on page 29 to determine factor.

   Example: (N) = 20; Factor = .268

3. Multiply (R) by factor -- answer is (SD).

   Example: (R) = 18; 18 x .268 = 4.82 (SD)

4. Divide (SD) by (M) -- answer is (C).

   Example: (M) = 15; $\frac{4.82}{15}$ = 32.1% (C)

(See continuation next page.)

5. Use formula $E = \frac{C}{\sqrt{N}}$

   Example: $E = \frac{32.1}{\sqrt{20}} = \pm 7.18\%$

6. For a specific accuracy level, multiply (E) by factor from Table II on page 30.

   Example: E = 7.18% -- accuracy level desired 95%
   N-1 = 19
   19 @ 95% level = 2.093
   7.18 x 2.093 = ± 15.03%

C. RULES OF THUMB:

1. Four times as many samples are required to obtain 95% accuracy level as are required to obtain 68% accuracy level.

   Example: N = 10 -- 68% accuracy level
   N = 40 -- 95% accuracy level

2. The limit of error (E) for the 95% accuracy level is two times that of the 68% accuracy level.

   Example: E = ± 20% -- 95% accuracy level
   E = ± 10% -- 68% accuracy level

TABLE I

RATIO OF STANDARD DEVIATION TO RANGE FOR SIMPLE RANDOM SAMPLES

N	$\frac{SD}{R}$	N	$\frac{SD}{R}$
2	0.886	12	0.307
3	.591	14	.294
4	.486	16	.283
5	.430	18	.275
6	.395	20	.268
7	.370	30	.245
8	.351	40	.231
9	.337	50	.222
10	.325		

From Snedecor's Statistical Methods (ed.5), Iowa State University Press.

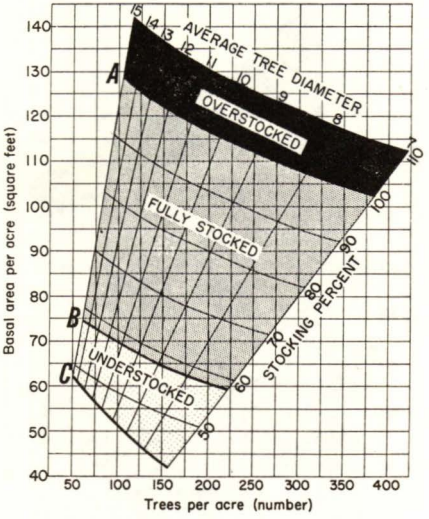
TABLE II

ACCURACY LEVEL TABLE

	Accuracy Level		
(N-1)	70%	95%	99%
4	1.190	2.776	4.604
5	1.156	2.571	4.032
6	1.134	2.447	3.707
7	1.119	2.365	3.499
8	1.108	2.306	3.355
9	1.100	2.262	3.250
10	1.093	2.228	3.169
11	1.088	2.201	3.106
12	1.083	2.179	3.055
13	1.079	2.160	3.012
14	1.076	2.145	2.977
15	1.074	2.131	2.947
16	1.071	2.120	2.921
17	1.069	2.110	2.898
18	1.067	2.101	2.878
19	1.066	2.093	2.861
20	1.064	2.086	2.845
21	1.063	2.080	2.831
22	1.061	2.074	2.819
23	1.060	2.069	2.807
24	1.059	2.064	2.797
25	1.058	2.060	2.787
26	1.058	2.056	2.779
27	1.057	2.052	2.771
28	1.056	2.048	2.763
29	1.055	2.045	2.756
30	1.055	2.042	2.750

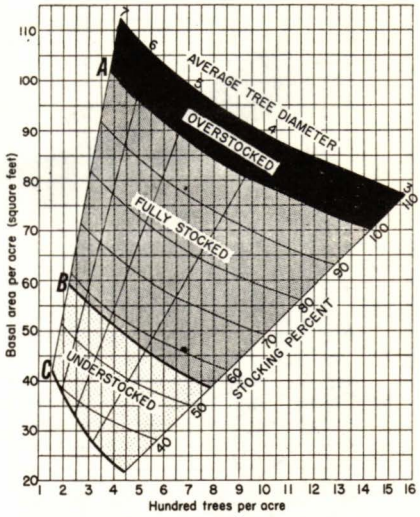
UPLAND CENTRAL HARDWOOD STOCKING GUIDE

Relation of basal area, number of trees, and average tree diameter to stocking percent for upland central hardwoods. Tree-diameter range 7-15 (left), 3-7 (right). The area between curves A and B indicates the range of stocking where



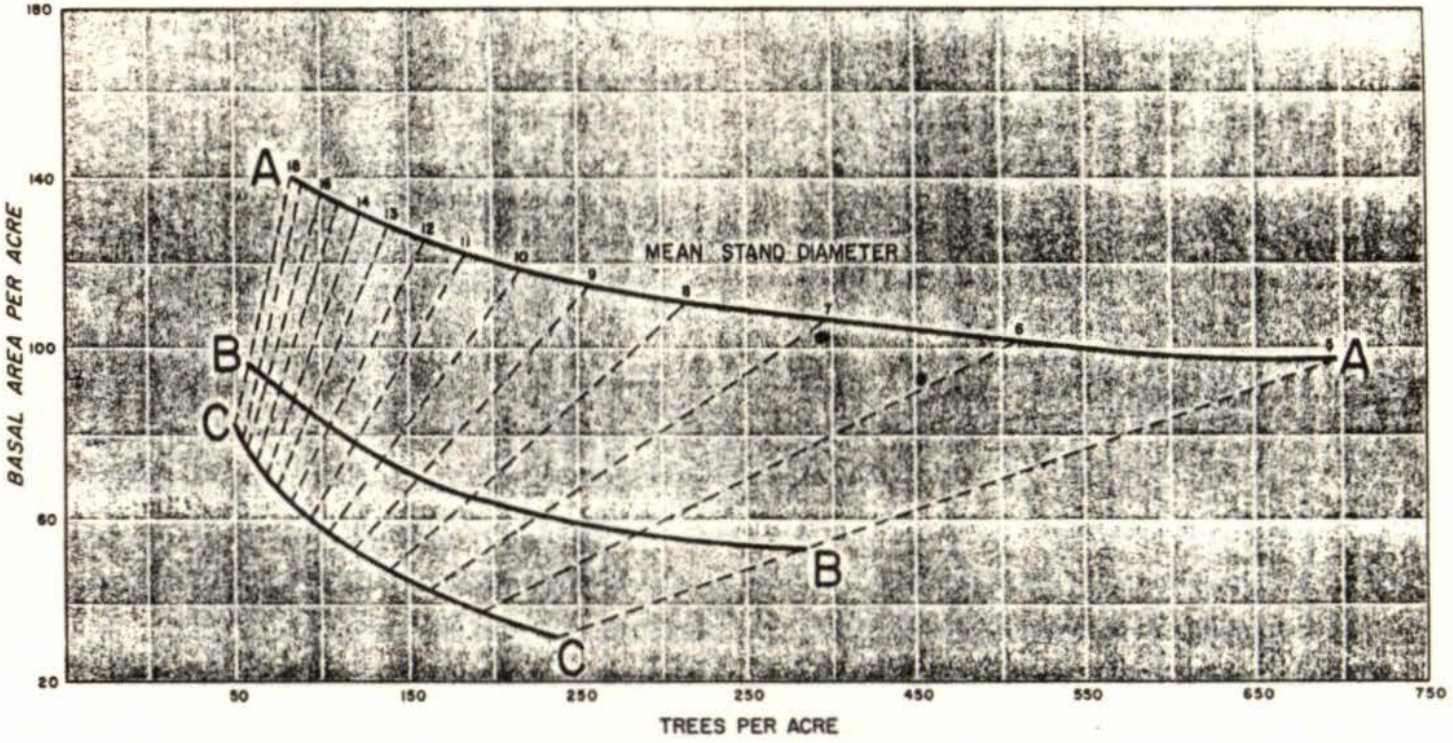
From: Timber Management Guide for Upland Central Hardwoods.

trees can fully utilize the site. Curve C shows the lower limit of stocking necessary to reach the B level in 10 years on average sites. (Average tree diameter is the diameter of the tree of average basal area.)



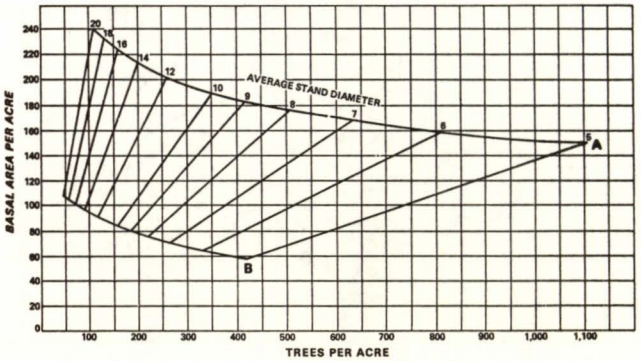
NORTHERN HARDWOOD STOCKING GUIDE

Stocking guides for even-aged northern hardwoods, based on number of trees in the main canopy, average diameter, and basal area per acre. Stands above the A line are overstocked. Stands between the A and B lines are adequately stocked. Stands between the B and C lines should be adequately stocked within 10 years. And stands below the C line are definitely understocked.



From: A Silvicultural Guide for Northern Hardwoods in the Northeast.

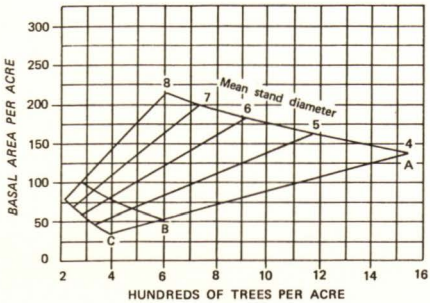
RED PINE STOCKING GUIDE

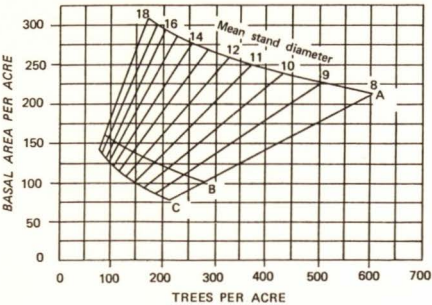


From: Managers Handbook for Red Pine in the North Central States.

WHITE PINE STOCKING GUIDE

(Philbrook et al. 1973)





☆U.S. GOVERNMENT PRINTING OFFICE: 1982—509-674